BRITAIN

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183/44

632,360 COMPLETE SPECIFICATION

1 SHEET

[This Drawing is a reproduction of the Original on a reduced scale.]

11 metal plate
14 - wool

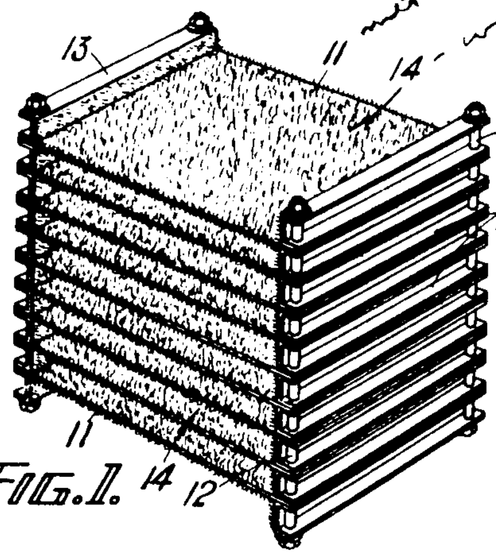

FIG.1.

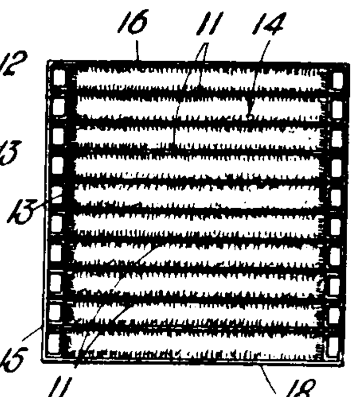

FIG.3.

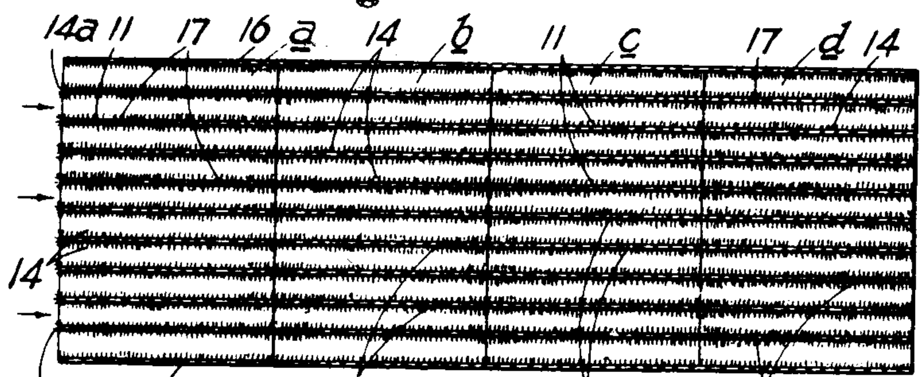

FIG.2.

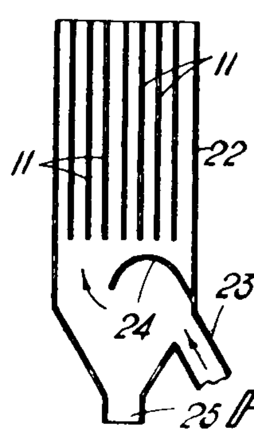

FIG.4.

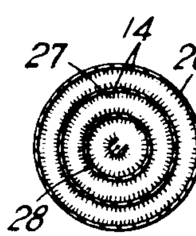

FIG.5.

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French 904,311

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PATENT SPECIFICATION 632,360

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Complete Specification Left: April 10, 1947.

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Index at Acceptance:—**Classes 7(ii)**, B2l, B2y(1 : 4 : 10c); **and 8(ii)**, D(1 : 3e2d).

PROVISIONAL SPECIFICATION.

Improvements in or relating to the Separation of Solid Particles from Air or other Gases.

I, ERIC VICTOR GILES, a British subject of Park Lodge, Stinchcombe Hill, Dursley, Gloucestershire, do hereby declare the nature of this invention to be as follows:

In the Specification of my patent 572,394 I have described devices for eliminating dust from air in which the air is directed along a tortuous channel lined with textile fabric presenting a surface of wool pile: the effect of the tortuous path is to cause the dust particles to impinge on the wall surface within which they are in great measure retained.

However, the tortuous flow may result in some cases in two imperfections. There is a tendency for the deposit of dust to be concentrated at those parts of the channel at which the most severe changes of direction take place, and the turbulence which inevitably accompanies travel in a tortuous path may be so violent as to pick up the finer dust particles from the wool surface, with the result that a portion of the dust is returned to the air stream. In the principal applications of such dust separators, for instance cleaning the air supply of internal combustion engines, the pressure drop allowable in the separator is but small, and the considerable pressure needed to drive the air through a tortuous channel can ill be afforded.

The present invention utilises a wool-coated surface as a means for retaining separated dust, but reduces the turbulence of the air to a minimum, forming the channel through which the air passes by straight parallel walls set but a short distance apart, and of such length that even a small component of velocity at right angles to the general flow will suffice to bring a dust particle into contact with the wool. If desired the wool may be made sticky with oil, or with a mixture of chlorinated wax and chlorinated rubber as described in my patent specification above mentioned.

In a preferred construction the separator of the invention is built of one or more horizontal channels of small vertical dimension lined with fibrous material presenting an appreciable depth of pile sufficiently close packed to hinder the flow of gas along the lining; and the length of the gas path through the separator channel is made such that the time of dwell of the air in the channel exceeds the time required for the finest and lightest particles to be separated to fall freely under gravity through the depth of the channel. However, it is not to be assumed that gravity is the only, or the principal cause of the dust particles reaching the wool. For most uses it is not practicable to make the separator of such size as to establish the conditions of laminar flow, but by using a number of channels in parallel the flow may be made so steady that even the finest particles are not picked up again when once they have entered the fibre pile.

The preferred lining material is a woven wool or wool and cotton fabric, the pattern of weave being such as to bring long floats of woollen yarn to one surface. The fabric is repeatedly subjected to known means of raising until a long and dense pile of fibre stands up from the surface completely concealing the original weave on that side of the fabric, while the other side is left smooth as it comes from the loom. The wool should be of the merino type in which the fabric present a great number of minute projecting scales.

The fabric is secured upon the metal walls of the separator by any convenient means.

Each channel or component channel should be lined top and bottom, for the top is effective in collecting and retaining dust, possibly because of outward eddies resulting from the boundary layers of the stream of air being retarded by the wool pile. Between the top and bottom linings there will be a free space along which the flow will chiefly occur: this space may be of very small depth or as large as an inch or so; the deeper it is the slower must be the linear speed of

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flow to avoid excessive eddies, and the longer will be the time needed for dust to deposit. The length of the channel will depend on the speed of flow and the depth of the channel.

To enable separators to be readily built for a wide range of purposes, it is convenient to build different separators from similar units. A separator unit may be contained within a rectangular endless casing about two feet long, six inches wide and six inches deep. Its side walls are formed with slots about three quarters of an inch apart to receive flat metal plates coated on both sides with fabric: this leaves about a quarter of an inch clear between the wool piles. The metal may be perforated to save weight. The wool coating is in one piece folded around the leading edge of the metal, which faces the incoming air, the margins of the metal sheet which enter the slots of the casing being left bare. The top and bottom of the casing may also be coated on the inner side, or may have an inserted plate immediately next to them. A number of such units may be connected in series or arranged in any convenient manner, bearing in mind the necessity of keeping losses due to friction at a minimum.

It may sometimes happen that the space available for the separator is such that the air channels cannot be placed horizontally or nearly so, but must be substantially vertical. The time during which the separator will operate without cleaning will be increased if the air is subjected to pre-cleaning, say, by reversal of its direction of motion, to cause the coarser dust to be flung out. The turbulence resulting may persist during most of the travel through the separator, and, if not too violent, may help in bringing the finer dust particles to the wool surfaces.

When the separator is used to clean the air entering a blower or an internal combustion engine it will be found that the separator greatly diminishes the noise of intake. The inlet manifold may be made with a **T** or **Y** end to which two separator units may be attached. The two branches of the intake may preferably differ in length by one half wave length of the note most prominently produced, to secure damping of noise by interference. To eliminate noise due to vibration of the casing it may be wool-coated on the outside, and supported in a perforated metal housing.

Dated this 11th day of April, 1946.

ARTHUR R. DAVIES,
Chartered Patent Agent,
Royal Chambers, Promenade,
Cheltenham.
Agent for the Applicant.

COMPLETE SPECIFICATION.

Improvements in or relating to the Separation of Solid Particles from Air or other Gases.

I, ERIC VICTOR GILES, a British Subject, of Park Lodge, Stinchcombe Hill, Dursley, in the County of Gloucester, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to the separation of solid particles from air or other gases.

In the specification of my prior Patent No. 572,394 I have described devices for separating dust from air in which the air is directed along a tortuous channel lined with textile fabric presenting a surface of wool pile: the effect of the tortuous path is to cause the dust particles to impinge on the wool surface within which they are in great measure retained.

However, the tortuous flow may result in some cases in two imperfections. There is a tendency for the deposit of dust to be concentrated at those parts of the channel at which the most severe changes of direction take place, and the turbulence which inevitably accompanies travel in a tortuous path may be so violent as to pick up the finer dust particles from the wool surface, with the result that a portion of the dust is returned to the air stream. In the principal applications of such dust separators, for instance cleaning the air supply of internal combustion engines, the pressure drop allowable in the separator is but small, and the considerable pressure needed to drive the air through a tortuous channel can ill be afforded.

As a result of research and experiment I have found that by passing an air or other gas stream contaminated with solid particles through a horizontal channel formed by straight parallel walls with the bottom wall treated to render it "infinitely sticky" the particles are retained by the latter and moreover the pressure drop between the ends of the channel is not substantially increased beyond that due to the normal flow of air through the channel (without particle separation). In fact, a perfectly satisfactory separator could be constructed on these lines if the stickiness of the bottom wall of the channel could be maintained, the particles being

retained by the sticky surface as they strike the latter due to their gravitational acceleration. For ease of reference herein this will be called the "terminal separation effect." However, quite apart from the practical difficulties of maintaining an infinitely sticky lower surface on the bottom wall of the channel, such a separating channel would be of inordinate length. This is particularly the case when the particles to be separated are small, my experiments having shown that the length of channel required for removing small particles by the terminal separation effect increases very rapidly as the size of the particles is reduced.

I have also observed that an unobstructed gap formed between straight parallel walls of a channel, one at least of which walls is lined with textile fabric presenting a pile surface to the gas stream, approximates fairly closely, so far as terminal separation is concerned, to the behaviour of the channel having an infinitely sticky surface as described above. Moreover, during experiments with such fabric-lined channels I have discovered that a gas stream entering the channel substantially devoid of turbulence assumes vortex flow in the channel, the finer and lighter contaminating particles in the stream entering into such vorticity and by this means being brought into intimate contact with the pile layer by which they are retained. It seems probable that the vortices in the gas stream are set up by the pile surface itself exerting a retarding effect on the boundary layer of the gas stream. Whether such is the case or not is immaterial, the important fact being that vortex flow results and enables the finer and lighter particles endowed with vorticity to be combed by the pile which retains them against re-entry into the gas stream. The nett result is the practical possibility of constructing a separator the pressure drop through which is small and which may be moreover of short length.

The invention accordingly comprises a method of separating solid particles from air or other gases contaminated therewith by passing the gas stream in a uni-directional flow through an unobstructed gap formed between straight parallel walls of a channel one at least of which walls is lined with textile fabric presenting a pile surface to the gas stream.

When particles of different sizes and or weights are present in the gas stream the cross-section of the aforesaid channel may be such that the finer and lighter particles are brought into contact with the pile due to vorticity whilst its length is at least such that the larger and heavier particles are removed by terminal separation. Or, where the range of particle sizes and or weights is very considerable, pre-cleaning of the gas stream to get rid of the larger and /or heavier particles may be resorted to with great advantage, as described hereinafter.

The opposite wall of the channel may also be fabric lined in the preferred arrangement according to the invention and certain conditions of effective spacing of the adjacent surfaces of pile fabric (or "gap," as it may be termed) may be adhered to in order to suit particular linear gas speeds, such that all the finer and lighter particles are brought into intimate contact with one or other of the opposite fabric-lined walls under the influence of vorticity, opposite vortices from the longitudinal centre line of the channel extending over the complete depth of the gap. Usually the straight parallel walls are at such spacing that the effective gap between the tops of the pile surfaces presented is of the order specified herein by way of example. The textile fabric employed is preferably a woven wool or wool and cotton fabric having a deep and dense pile of wool upon the surface presented to the gas stream. The pile may advantageously be made sticky with oil, or with a mixture of chlorinated wax and chlorinated rubber as described in my patent specification above mentioned, or with any other suitable material which should be a liquid having a low freezing point when the separator is to be used at high altitudes and low temperatures, as for example in aircraft.

In order that the invention may be carried into effect a preferred embodiment thereof will now be described by way of example. In this embodiment the separator is built of one or more horizontal channels of small vertical dimension lined with fibrous material presenting an appreciable depth of pile sufficiently close packed to hinder the flow of gas along the lining; and the length of the gas path through the separator channel is made such that the larger and/or heavier particles reach the pile under gravitational acceleration, the finer and/or lighter particles being brought into contact with the pile due to vorticity in the manner already mentioned. For most applications it is convenient to use a number of channels in parallel with the effective gap, i.e. the distance between the tops of the opposing piles, so small that terminal separation of the larger and/or heavier particles is achieved whilst the flow is so steady that even the finest particles are not picked up again when they have entered the fibre pile.

The lining material employed may be a woven wool or wool weft and cotton warp fabric, the pattern of weave being such as to bring long floats of woollen yarn to one surface. This surface of the fabric is finished by repeatedly subjecting it to known means of raising, for example on a raising machine of the "Moser" type, until a long and dense pile of fibre stands up from this surface completely concealing the original

weave on that side of the fabric, while the other side is left smooth as it comes from the loom. The raising process should be carried out not too rapidly as otherwise a scraggy and uneven result will be obtained, whereas a dense and even pile is of primary importance. The wool should be of the merino type in which the fibre presents a great number of minute projecting scales.

The channels are defined between metal plates maintained in suitably spaced parallel relationship, and fabric of the character described is secured upon the metal walls of the separator by any convenient means. Each channel or component channel should be lined top and bottom, for the top is effective in collecting and retaining dust, because of vortices outwardly directed from the central or main flow through the channel and possibly resulting from the boundary layers of the stream of air being retarded by the wool pile. Between the tops of the opposing pile surfaces there will be a free space along which the flow will chiefly occur; this space or gap may be of very small depth, for example five eighths of an inch or less, although in certain cases where the channel is of considerable length or where a series of channels are arranged in staggered relationship one behind the other, the gap may be as large as an inch or so. For a given efficiency of separation the length of the horizontal channel will depend on the speed of flow and the depth of the gap. In this connection my investigations have shown that the following relationship exists between the linear speed of flow, the depth of the "gap" and the efficiency of separation:

$$\theta = (k - ad) - (bd - c)\,V$$

where θ is the percentage efficiency of separation in terms of the ratio of the mass concentration of contaminant at the inlet and outlet ends of the channel:

d is the "gap" or effective depth of channel between the tops of the opposing pile surfaces in ins.,

V is the linear speed of flow in ft./min., and a, b, c and k are constants.

In straight, parallel-walled channels formed between adjacent flat plates disposed in parallel planes, i.e. when the cross section of the channel is of constant rectangular shape, and without oiling or otherwise treating the fabric to make it sticky, the constants a, b, c and k are:—

$$a = 40$$
$$b = .036$$
$$c = .008$$
$$k = 109$$

The above formula applies substantially equally to straight, parallel-walled channels formed between coaxial cylinders, i.e. when the cross-section of the channel is of constant annular shape.

In addition to the foregoing relationships my experiments have shown that, with flow of solid particle-contaminated gas through the fabric-lined, straight, parallel-walled channels with which I have been working, the pressure drop through the channel is independent of the quantity of particles trapped by the fabric. Based on this fact an investigation has been made of the variation of pressure drop in relation to other variables, such as linear speed of gas flow, length of channel and depth of channel or gap and the following empirical formula obtained:—

$$H = q\left[\frac{V^n}{d^m}\right]\left[\frac{L}{i}\right]$$

where H is the pressure drop in ins. water gauge, and q, i, n and m are constants, with

$$q = .0000251$$
$$i = 24$$
$$n = 1.78$$
$$m = 1.48$$

This formula has been proved accurate for the range covered by my present investigations which have covered linear speeds of flow from 500 ft./min. to 3000 ft./min. and gaps from 1 in. to .25 in. and it seems probable that the same relationship will hold substantially outside these ranges, for example with speeds of flow up to 10,000 ft./min.

Separators constructed in accordance with the invention have shown themselves to be non-selective of particle size, which is regarded as of importance inasmuch as high separation efficiencies are maintained even with particles below, say, 40μ. Moreover, it is a surprising fact that high separation efficiencies of the smallest and lightest particles are obtained even with channels of short length.

EXAMPLE.

Utilising a separator providing a plurality of straight, parallel-walled channels of constant rectangular cross-section having their upper, lower and side walls lined with pile fabric air flows of 300 to 500 cub.ft./min. were contaminated with solid particles to the amount of .03 gms./cub.ft. of air passing through the channel. An analysis of the particles used is as follows:—

Percentage by Weight.	*Particle Size.*
Not more than 1%	152μ and above.
Between 30% and 40%	Between 76μ and 152μ.
Between 20% and 30%	Between 76μ and 20μ.
Between 20% and 30%	Less than 20μ.

The separator was constructed from four of the standard separator units described hereinafter arranged in series, so that the overall dimensions are approximately:— length two feet, width eight inches and depth eight inches. As previous tests had

shown that somewhat higher efficiencies of separation are invariably obtained when the fabric is oiled or otherwise treated to render it sticky, the present series of runs were carried out with dry fabric. The contaminated air was passed through the separator channels by means of a suitable fan, fitted with a throttle on the exhaust side, the particles being induced into the air stream by means of an air-fed injector. The linear speed of air flow varied directly as the effective cross-sectional area of the channel. An analysis of the particles trapped was as follows :—

Particle Size.	*Percentage of Trapped Particles.*
152μ and above	1%
Between 76μ and 152μ	30%
Between 40μ and 76μ	30%
Below 40μ	39%

To enable separators according to the invention to be readily built for a wide range of purposes, it is convenient to build different separators from similar units. A suitable size of separator unit has been found to be six inches long by eight inches wide by eight inches high and, as shown in Figure 1 of the accompanying drawings, such unit may consist for example of nine metal plates 11 each six inches long by eight inches wide and maintained in parallel relationship about three quarters of an inch apart upon rods 12 having distance pieces 13 between the plates. In this example the pile fabric is attached to both sides of each plate, as indicated at 14, the effective gap resulting from the use of this fabric and the distance pieces 13 being about three eighths of an inch. As will be seen from Figure 1, the distance pieces 13 are in the form of channel section elements having pile fabric attached to the inwardly presented vertical surfaces of the channels whereby all four sides of each channel present a pile surface to the gas stream. If desired units of this construction may be used together in series or parallel, as required for any particular application. Or, as illustrated in longitudinal section and end elevation respectively in Figures 2 and 3 of the drawings, the plates 11 (preferably without the rods 12) may be contained within a rectangular endless casing 15 about two feet long and eight inches wide and eight inches deep, through which the gas flows in the direction of the arrow in Figure 2, four of the units being disposed in series, as represented diagrammatically at *a*, *b*, *c* and *d*. The flat metal plates 11 are coated on both sides with fabric and plates 16 and 18 having the pile fabric attached to their inner sides only are mounted directly against the top and bottom walls of the casing where they are spaced from the adjacent plates 11 by the end distance pieces 13, as shown in Figure 3. As before, this leaves about three-eighths of an inch clear between the adjacent wool piles. In order to equalise pressures on each side of the plates 11 the metal of which they are made may be perforated, as shown for example at 17. The wool coating 14 may be in one piece folded around the leading edge of the metal which faces the incoming air, as shown at 14*a* in Figure 2, or it may be formed of two separate sheets of fabric of substantially the same size as the plate and stuck thereto one on each surface.

It may sometimes happen that the space available for the separator is such that the air channels cannot be placed horizontally or nearly so, but must be inclined or substantially vertical. Such an arrangement is quite practical as, although the terminal separation effect already referred to diminishes substantially in proportion to the inclination of the channels, the vorticity in the gas stream ensures efficient separation. An example is given in Figure 4, where 22 illustrates a vertical rectangular casing subdivided into rectangular air channels by the fabric-covered plates 11 and through which channels the gas flows in an upward direction. As already stated, where the range of particle sizes and/or weights is considerable, pre-cleaning of the gas stream to get rid of the larger or heavier particles may be very advantageous. The time during which the separator will operate without cleaning may also be increased if the air is subjected to pre-cleaning, say, by reversal of its direction of motion, to cause the coarser particles to be flung out. One pre-cleaning arrangement is illustrated diagrammatically in Figure 4 where air entering the casing by way of an inlet pipe 23 is initially projected against a hook-shaped deflector member 24 where the larger and/or heavier particles after impact against the deflector fall into the neck portion 25 of the casing and may be removed periodically by unscrewing a cap therefrom. It will be understood that the deflector member 24 is essentially a pre-cleaning arrangement and does not enter into the separator action taking place in the parallel-walled channels ; in this connection it should be observed that although the member 24 has been diagrammatically shown arranged close to the inlet ends of the channels this is only to facilitate illustration and in practice the pre-cleaning device, when employed, is placed at some considerable distance therefrom.

In Figure 5 of the drawings a construction of separator is shown in diagrammatic cross-section in which the casing 26 is cylindrical and the straight, parallel-walled channels are formed between coaxial cylinders or plates 27 and 28 covered with fabric as already described.

When a separator according to the invention is used to clean the air entering a blower

or an internal combustion engine it will be found that the separator greatly diminishes the noise of intake. The inlet manifold may be made with a **T** or **Y** end to which two separator units may be attached. The two branches of the intake may preferably differ in length by one half wave length of the note most prominently produced, to secure damping of noise by interference. To eliminate noise due to vibration of the casing it may be wool-coated on the outside, and supported in a perforated metal housing.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is :—

1. The separation of solid particles from air or other gases contaminated therewith by passing the gas stream in a uni-directional flow through an unobstructed gap formed between straight parallel walls of a channel, one at least of which walls is lined with textile fabric presenting a pile surface to the gas stream.

2. The separation of solid particles of different sizes and/or weights from air or other gas contaminated therewith by passing the gas stream through an unobstructed gap formed between straight parallel walls of a channel one at least of which walls is lined with textile fabric presenting a pile surface to the gas stream, the cross-section of the channel being such that the finer and/or lighter particles are brought into contact with the pile due to vorticity and its length being at least such that the larger and/or heavier particles reach the pile before the gas stream leaves the channel.

3. The separation of solid particles from air or other gases contaminated therewith according to Claim 1 or 2, wherein the opposite straight parallel wall of the channel is also lined with the fabric.

4. A method according to Claim 2 or 3, which comprises the steps of pre-cleaning the gas stream to remove the larger and/or heavier particles and subsequently passing it through said channel to remove the larger and/or heavier of the particles remaining by gravity and the finer and/or lighter particles by vorticity.

5. A method according to any of the preceding claims, wherein the textile fabric is a woven wool or wool and cotton fabric subjected to raising to produce a deep and dense woollen pile upon the surface presented to the gas stream.

6. A method according to any of the preceding claims, wherein the textile fabric is made sticky with oil or with a mixture of chlorinated wax and chlorinated rubber or with any other suitable liquid material.

7. A method according to any of Claims 3 to 6, wherein the gap or effective spacing of the fabric-lined walls is chosen in accordance with the following relationship :—

$$\theta = (k - ad) - (bd - c)V$$

where θ is the required percentage efficiency of separation in terms of the ratio of the mass concentration of contaminant at the inlet and outlet ends of the channel.

d is the gap or effective spacing of the fabric-lined walls in ins.

V is the linear speed of gas flow in ft./min., and

a, b, c and k are constants.

8. A method according to any of the preceding claims, wherein the gas stream is passed through a plurality of channels in parallel, i.e. the gas stream flows simultaneously and in the same direction along such plurality of channels.

9. Means for separating solid particles from air or other gases contaminated therewith comprising a casing which provides a channel open at each end and between straight parallel walls of which an unobstructed gap is formed, at least one of said walls being lined with textile fabric presenting a pile surface of the gap.

10. Means according to Claim 9, wherein the casing contains a plate parallel to the walls of the casing to form a plurality of such straight, parallel-walled channels.

11. Means according to Claim 10, wherein the casing and plate are coaxial cylinders forming between them a channel of constant annular shape in cross-section.

12. Means for separating solid particles from air or other gases contaminated therewith by the methods of any Claims 1 to 9.

13. A method of separating solid particles from air or other gases contaminated therewith substantially as herein described.

14. Means for separating solid particles from air or other gases contaminated therewith substantially as herein described with reference to the accompanying drawings.

Dated this 9th day of April, 1947.

ARTHUR R. DAVIES,
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Agent for the Applicant.

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